11. Description and Characteristics of Alternatives

As part of the remedial action selection process leading to this ROD, EPA developed and evaluated five remedial alternatives. Each remedial alternative considered in the JGWFS, other than the No Action Alternative, contains: (1) a set of remedial actions for the chlorobenzene plume, (2) a set of remedial actions for the benzene plume, and (3) a set of remedial actions for the TCE plume. The JGWFS considered and evaluated potential interrelationships among the remedial actions for each plume in the process of assembling the alternatives. Alternatives and actions which would not be protective or would not attain applicable or relevant and appropriate requirements (ARARs) in a reasonable time frame were eliminated from further consideration prior to the detailed analysis of alternatives.

The JGWFS demonstrated that it is feasible to reduce and eliminate the volume of groundwater in the chlorobenzene plume outside the containment zone, while containing the contamination within the containment zone. The alternatives span three differing degrees of relative aggressiveness with respect to reducing the volume of the chlorobenzene plume outside the containment zone, in association with various combinations of means for containing the containment zone (recall that the chlorobenzene plume is the only plume with contamination *outside* the containment zone). This section describes the characteristics of these alternatives and Section 12 evaluates and compares them according to the nine NCP criteria.

Before the alternatives are described, several foundational aspects for the alternatives are documented. These evaluations provide a factual context for the alternatives that EPA considered in selecting this remedial action. Because this adds significant length to this section, the following outlines the section to assist the reader. Note that the actual description of elements within the alternatives does not begin until Section 11.3.

In Section 11.1, foundations and context for alternatives are discussed, including: (1) EPA's consideration of the potential for adverse contaminant migration, (2) critical aspects and limitations of the groundwater model that was used, (3) the potential and basis for reliance on intrinsic biodegradation as a remedial mechanism in alternatives, (4) situational aspects related to the TCE plume and why only one remedial option was appropriate for the TCE plume, (5) situational aspects related to the compound pCBSA, and (6) EPA's approach to alternatives. It is noted that alternatives and scenarios which EPA screened out in the JGWFS generally are *not* discussed in the ROD and the reader should consult the JGWFS for this information. Section 11.2 discusses factors related to measuring and addressing time frames for the remedial action, and the concepts of early time performance and pore volume flushing. Section 11.3 identifies the elements of the five alternatives which are common to all alternatives, other than the No-Action alternative. Section 11.4 identifies the differentiating elements among the alternatives. Section 11.5 discusses treatment technologies and treated water discharge.

11.1 Foundation and Context for Alternatives

Consideration of Potential for Action Interrelationships and Adverse Migration

As discussed in Section 4, the various areas of groundwater contamination within the Joint Site are interrelated, and hence EPA has addressed it as a single operable unit. Factors evaluated in the development of remedial alternatives and the assessment of their feasibility during this remedial selection process included but were not limited to the potential for (1) remedial action interrelationships and (2) adverse migration of contaminants. The former refers to the movements of contaminants that might occur in other plumes in response to remedial actions that are designed and primarily targeted toward one plume. The latter refers to the undesired movement of contamination, including NAPL, in a manner that would violate the objectives of the remedial action. Before alternatives were ever constructed, the focus in defining, screening, and evaluating alternative prototypes in the JGWFS was to meet all remedial objectives for each plume while at the same time limiting or minimizing the potential for adverse migration of contaminants.

Migration of this type *could* include:

1. Movement of contaminants laterally or vertically in a manner which would make them more difficult to contain, or unacceptably increase the uncertainty associated with containing them within the containment zone;

2. Movement of contaminants in such a manner as would retard the attainment of remedial action standards set in this ROD (including but not limited to the attainment of drinking water standards for water outside the containment zone), or unacceptably increase the uncertainties associated with such attainment; or

3. Movement of contaminants that results in a spreading of the contamination to a larger area or to areas more likely to pose a risk from groundwater use.

Site-specific examples of potential remedial action interrelationships and adverse migration that EPA considered and accounted for in the remedial selection process include:

1. The potential for inducing NAPL to migrate downward or laterally in response to hydraulic extraction intended to contain the NAPL or reduce the plume outside the

containment zone. Such movement, potentially caused by reducing interstitial pore pressures or increasing vertical and lateral hydraulic gradients in the areas where NAPL occurs might: (1) threaten the ability of the remedial actions selected by this ROD to contain contaminants within the containment zone, (2) cause greater and more wide-spread migration of dissolved phase contamination associated with the NAPL, (3) lengthen and complicate the time necessary to achieve remedial objectives, and (4) potentially complicate the removal of NAPL by remedial actions being considered in the second phase of the groundwater remedy.

2. The potential for movement of the benzene plume downward or laterally in response to hydraulic extraction primarily focused on containing or reducing the chlorobenzene plume. This movement could result in the spreading of the benzene plume to areas of groundwater where it does not presently occur, including areas outside the containment zone and in the lower hydrostratigraphic units. In addition, more dissolved benzene could migrate into the chlorobenzene plume, in which biodegradation of benzene appears to be slower and less effective in reducing benzene mass.

3. The potential for movement of TCE downward or laterally in response to hydraulic extraction primarily targeting the chlorobenzene plume.

4. Potential for movement of contaminants from outside the Joint Site into the Joint Site in response to remedial actions being evaluated.

In the course of the remedy selection process, EPA has found that it is feasible to limit, control and even eliminate adverse migration of contaminants by a proper remedial design of the remedy. The JGWFS and the remedial selection process thoroughly evaluated the potential for adverse migration, considered the costs and benefits from the standpoint of the entire remedial action, and formulated remedial alternatives capable of controlling and limiting the impacts of such factors *while still meeting all other goals and objectives of the remedial action*, including but not limited to attaining ARARs in a reasonable time frame, and maintaining protectiveness of human health and the environment over the long term.

This does not mean that all the alternatives ultimately considered present the same risks with respect to adverse migration. In fact, some of the differences in such risks among the alternatives form a major basis for EPA's selection of one alternative over another. However, the alternatives have been constructed from the beginning of the JGWFS effort to take the potential for adverse migration into account, and the alternatives ultimately evaluated in detail by the JGWFS therefore encompass a reasonable range with respect to such potential. The appropriate alternative for selection therefore lies within that range.

EPA has not specified in this ROD that no adverse migration of contaminants shall occur at all, nor has it specified that the potential for such migration shall be completely eliminated. While the JGWFS has shown that it should be feasible to adequately limit adverse migration of NAPL or dissolved phase contaminants and still meet remedial action objectives, it is possible that some adverse migration could occur during remedial implementation. This ROD contains provisions for such a possibility, requiring that the remedial design be adjusted to reverse and contain the adverse migration. It is crucial to note that limiting adverse migration of contaminants shall not take preeminence over all other performance criteria and remedial action objectives of the selected remedial action. Rather, limiting adverse migration shall take place within the context of meeting all such requirements, including but not limited to attaining ARARs in a reasonable time frame, and attaining the required rate of reduction in the volume of the chlorobenzene plume outside the containment zone.

Therefore, for example, the remedial action shall be designed to reduce the chlorobenzene plume with the rate and efficiency required by this ROD. If, once the remedial action is implemented, adverse migration occurs at some location within the Joint Site, this ROD would require that additional wells or systems be implemented as required to minimize and contain that migration, as opposed to slowing the rate of cleanup by pumping less on the chlorobenzene plume. The former would represent adjusting to the migration within the context of continuing to meet ROD objectives. The latter would represent addressing migration at the expense of meeting ROD objectives.

Because potential remedial action interrelationships and adverse migration were considered intrinsically to the process of developing alternatives:

1. The remedial actions for each plume within each alternative are different than they would otherwise be if each plume had been considered independently and irrespective of the others. For instance, it is likely, though not certain, that EPA would have considered more aggressive cleanup rates for reducing the size of the chlorobenzene plume outside the containment zone, if the benzene plume did not exist. EPA did not do so because it had to keep the potential for adverse migration of the benzene plume, given potential influence from pumping on the chlorobenzene plume, within a reasonable range.

2. For each remedial alternative, the potential changes in drawdowns and gradients in the area of the DNAPL imposed by hydraulic extraction were evaluated, using the numerical model of the Joint Site groundwater discussed below. The locations and flow rates of wells in all considered alternatives were then adjusted to minimize the changes in gradients in the NAPL area. The results of modeling demonstrate the feasibility of limiting the inducement of NAPL migration under all remedial alternatives considered.

3. The JGWFS demonstrates that the goal of attaining ISGS levels in the aquifer outside the containment zone can be achieved without undue risks of adverse migration, if designed properly.

While it was appropriate for the JGWFS to evaluate the interrelationships among separate actions for each of three plumes, the remedial action as selected, designed, and implemented should not be considered a simple union of three disparate actions, but rather a unified whole addressing all requirements of the ROD. The various actions within the selected remedial action will be optimized together in the remedial design phase. To facilitate analysis, there is reference in the JGWFS and this ROD to separate wellfields [1] ("chlorobenzene wellfield," "benzene wellfield," etc.) but, in the final sense, the selected remedy will contain one optimized wellfield. Extraction and injection wells in the final design will generally serve a primary purpose with respect to one of the three plumes, yet may also have one or more purposes with respect to the other plumes, depending on the location of the wells. The description of alternatives in this section and the following section refer to actions for each plume separately to facilitate the documentation of the remedy selection process and to remain consistent with the feasibility study. But it should be remembered that remedial selection and design is not separable among the plumes.

The Joint Groundwater Model

A primary tool in the effort to evaluate (1) the performance of various remedial actions, (2) the potential for remedial action interrelationships, and (3) the potential for adverse migration of contaminants, was a computer-based groundwater flow and contaminant transport model. It is noted that the model was not the *only* tool used by EPA in these evaluations, and not all scenarios and types of movements were evaluated with the model (e.g., remedial actions focused on the TCE plume were not evaluated with the model). Also, the model (as with all models) has limitations which made it inappropriate for certain types of evaluations, as discussed in the JGWFS and briefly below. The model was used to the extent appropriate given its objectives, limitations, the data available, and the extent to which the model was necessary. An understanding of the modeling objectives and limitations is essential for the evaluation of alternatives and selection the remedial action in this ROD.

MODFLOW, a three-dimensional finite difference model, was used to simulate groundwater flow at the Joint Site. MODFLOW was linked to the transport model MT3D for the simulations

[1] Note: A "wellfield" refers to a particular configuration and number of hydraulic extraction and/or aquifer injection wells in physical space. Hydraulic extraction wells pull water toward themselves and create a cone of depression in the water table or in the head (pressure) distribution of the aquifer in which they operate. Injection wells push water away from themselves and create a "mounding" in the water table or an area of increased pressure in the head distribution of the aquifer in which they operate. In design, wellfields are generally varied until simulations of their operation produce the intended hydraulic effect on the aquifer system as a whole.

of contaminant transport. The model domain was a rectangular area centered on, and extending beyond, the Joint Site, incorporating known and potential sources of contamination which lie in the vicinity of the Joint Site. The model grid consisted of 5,229 rectangular cells of 200- by 200-foot size in the primary area of interest, and 200- by 400-foot cells in the peripheral areas. Vertically, the model was divided into 13 layers of variable thickness to represent eight affected hydrostratigraphic units discussed in the JGWFS and in the previous sections of the ROD. Hydrogeologic properties were assigned to the model based on the results of remedial investigations performed at the Montrose and Del Amo Sites. In the peripheral portions of the model domain, hydraulic conductivities were interpolated based on a sequential gaussian protocol. The initial conditions for the contaminant plumes were assigned to the model based on contaminant distribution data collected during remedial investigations (See Section 2 of the JGWFS and the RI Reports; See Section 5 of this ROD). Fixed source term concentrations were used for areas of detected and suspected NAPL.

The model used for this analysis was a well-designed and highly useful tool for providing a basis for a comparative evaluation of remedial alternatives and an assessment of the approximate size and configuration of remedial systems required on a fairly large-scale. These are the purposes to which EPA has put the model in its analysis of alternatives for the Joint Site.

At the same time, the results of the groundwater model should only be seen in the context of, and as properly restricted by, the model's limitations. All models have uncertainties and limitations. EPA's intention in discussing them in this ROD is not to cast doubt on the quality or validity of the model or the modeling design effort used in this case. Rather, the intention is to establish that the model cannot be used for all purposes. Also, modeling results cannot be blindly trusted but must be accompanied by an assessment of the degree of certainty that can be attributed to them, given the nature of the input data and of the model itself. Some results provide greater certainty than others.

The modeling limitations applying to the model used for the JGWFS, and the reasons for them, are addressed in detail in Section 5 and Appendix B of the JGWFS. While the limitations do not diminish the valid uses of the model, they are critical to this remedy. Of particular note are the following:

- The model cannot be used to reliably simulate *absolute* cleanup time frames. Therefore, the evaluation of alternatives with respect to the cleanup time frame was focused on the relative rate of approaching complete cleanup (attaining remedial action objectives at all points in groundwater).

  One of the reasons that the model cannot accurately estimate the total times to reach remedial objectives at all points in the Joint Site groundwater is that the model cannot account for sorption tailing effects, which mean that contaminant desorption from soils can occur at a slower rate than the rate at which sorption occurs (See Section 5 and Appendix B of the JGWFS). As a result, the simulated time frames from the modeling effort are likely to be shorter than the actual time required to complete the cleanup. While there are also other factors of which the model cannot account, such as potential unmeasurable intrinsic biodegradation, that may serve to lessen the actual cleanup times compared to simulated cleanup times, it is likely that the sorption tailing effects will dominate (See EPA's response to Montrose Chemical Corporation in the Response Summary to this ROD).

- The longer the time frame simulated, the greater the uncertainty associated with the modeling result. While the time to reach remedial objectives at all points in the Joint Site groundwater will likely be on the order of 100 years, simulations greater than the order of 50 years into the future are generally not reliable or useful. EPA has used simulations of 10-25 years for comparing remedial alternatives, even though the remedial action is not complete in that time frame under any of the alternatives. This provides a measure of each alternative's *relative* performance and progress at 25 years toward meeting the remedial objectives.

- The model cannot account for or simulate local small-scale heterogeneities and preferential flow paths, which could provide an explanation for some of the observed contaminant distributions. This is primarily for two reasons:

  1) The model has a limited resolution (cell size 200 by 200 feet), hence, the model cannot accurately estimate movements of water and contaminants along the potential preferential flow paths that are smaller than the size of one cell.

  2) Local heterogeneities and preferential flow paths may be only a few feet or tens of feet in size, yet still be able to affect contaminant fate, transport, and distribution. The data from the remedial investigations are not sufficient to define heterogeneities of such a size, nor would it be practicable to obtain such data in most cases.

- The modeling results for vertical transport from the MBFC Sand through the LBF to the Gage Aquifer, and for vertical transport from the Gage Aquifer through the Gage-Lynwood Aquitard to the Lynwood Aquifer, are associated with such high uncertainty as to be largely unreliable (See Section 5 and Appendix B of the JGWFS). EPA did not use the model for these purposes.

- The model cannot be used to simulate movement of the chlorobenzene plume in the MBFB Sand (water table units) near the former Montrose plant because of the high level of uncertainty associated with the hydrogeologic parameters of the MBFB Sand in this area (See Sections 2 and 5 of the JGWFS).

Key Findings of the Joint Groundwater FS

The model was not used as the exclusive determiner but rather as one tool in reaching these findings. The model was not used in reaching all of these findings. Among the key findings of the JGWFS are the following:

- Hydraulic containment (isolation) of the NAPL at the Joint Site feasibly can be achieved. The size of the containment zone must be somewhat larger than the actual physical dimensions of the DNAPL source to avoid the adverse impacts of hydraulic extraction on the migration of NAPL. The associated pump rates have been approximated with assistance from the model.

- Adverse downward migration of chlorobenzene DNAPL can be avoided by strategic placing of hydraulic extraction wells (pumping wells) in such a manner that hydraulic impact from these wells in the DNAPL zone is minimal (if any)

- Injection of treated water is considered a *necessary* component of the alternatives for the chlorobenzene plume, because it minimizes potential adverse migration of NAPL and the benzene and TCE plumes, minimizes the hydraulic impact on sources of contamination at the periphery of the Joint Site, and assists in preventing dewatering of the aquifers during extraction and treatment.

- Reducing the volume of the chlorobenzene outside the containment zone (i.e. restoration of the chlorobenzene plume) is feasible. Three different wellfields were examined which fall on a scale of increasing relative aggressiveness: a 350 gallon-per-minute (gpm) wellfield, a 700-gpm wellfield, and a 1400-gpm wellfield. The long and short-term performance of these wellfields has been evaluated and is described in the JGWFS, and is discussed and summarized in this ROD in Sections 11 and 12.

- It is feasible to minimize or eliminate adverse movements of the benzene plume and TCE plume were hydraulic extraction in the chlorobenzene plume to occur at any of the three degrees of relative aggressiveness (in terms of pumping rates) considered. Optimization of the wellfields would be necessary in remedial design, however.

- Hydraulic influences on contaminant sources outside the Montrose and Del Amo Sites and plumes, such as the Mobil Refinery to the west and the McDonnell Douglas facility to the north of the former Montrose plant, can be mitigated if treated water is injected in the aquifer (aquifer injection) as part of the remedial action.

- If no action is taken for the chlorobenzene plume, it will likely continue to migrate, as determined by the evaluation of the fate and transport of chlorobenzene including numerical modeling (See Montrose RI Report and Section 5 of the JGWFS).

- If no action is taken for the TCE plume, it will likely continue to migrate, as determined by the evaluation of fate and transport of TCE including numerical modeling (See Del Amo Groundwater RI Report and Section 5 of the JGWFS). The modeling results for the TCE plume are less certain than for the chlorobenzene plume.

- Little reduction in the volume of the benzene plume can be attained by pumping it, because of the presence of multiple LNAPL sources that cannot be isolated from the rest of the benzene plume. (See Appendix E of the JGWFS and Section 10 of this ROD). In addition, hydraulic containment of the benzene plume in the UBF and MBFB Sand provides little-to-no benefit compared to reliance on intrinsic biodegradation only (See Section 5 of the JGWFS). The benzene plume in the MBFC Sand feasibly can be contained by pumping, however, and there are reasonable benefits to be considered from such pumping. This is further discussed in Section 12 of this ROD and in Section 5 of the JGWFS.

Potential for Reliance on Monitored Intrinsic Biodegradation

Section 7.3 of this ROD briefly addressed the presence of intrinsic biodegradation of contaminants as a matter of site characteristics. As discussed there, intrinsic biodegradation is a form of natural attenuation which occurs when innate microorganisms metabolize site contaminants (See Section 7.3 and the JGWFS).

This section evaluates intrinsic biodegradation at the Joint Site from the standpoint of the potential to *rely* on it as a mechanism to meet remedial objectives. Intrinsic biodegradation can slow, halt, or reverse the outward migration of a dissolved phase contaminant in groundwater. Hence, EPA evaluated the potential for utilizing it as a means of containing all or portions of the containment zone. However, intrinsic biodegradation only occurs under certain conditions, and with certain contaminants. To rely on intrinsic biodegradation in a remedial context, it must not only be present but there must be enough confidence that it will reliably achieve the remedial objective for which it would be used. It is possible to have confidence in the presence of intrinsic biodegradation, but low certainty with respect to its ability to meet remedial objectives.

For the Joint Site, intrinsic biodegradation was considered potentially reliable for *containment* of the benzene plume, and is incorporated in the remedial alternatives as a containment mechanism to varying degrees for the benzene plume. However, intrinsic biodegradation was not considered potentially reliable for containment of the chlorobenzene and TCE plumes, and was not incorporated into alternatives for these plumes. Intrinsic biodegradation also was not considered potentially reliable for reducing the volume of contamination outside the containment zone, and was not incorporated into alternatives for this purpose. The basis for this is described further below.

Potential for Reliance on Intrinsic Biodegradation in the Benzene Plume

Recalling Sections 9 and 10, the remedial objectives for the benzene plume include only containment; there is no portion of the benzene plume, which lies *outside* the containment zone/TI waiver zone.

At the Joint Site, there is significant evidence of *reliable* intrinsic biodegradation of the benzene plume in the UBF and the MBFB Sand. The factors present with respect to the benzene plume that support the ability to rely on intrinsic biodegradation as a remedial mechanism for this portion of the benzene plume include several of those listed in Section 7.3:

- The concentration gradients at the leading edge of the benzene plume are steep;
- The lateral extent of the dissolved plume outside of the NAPL sources is small;
- The benzene plume is much smaller than what would be expected based on groundwater velocity and expected retardation in the absence of intrinsic biodegradation; benzene has not migrated far from the NAPL sources despite likely being in the ground 20-40 years;
- The plume appears to be stable and does not appear to be migrating laterally;
- In-situ measurements of geochemical parameters (e.g. dissolved oxygen, nitrate, sulfate, methane, etc.) indicate biological activity that is related to (varies spatially with) the benzene concentration in groundwater;
- Biodegrader organism counts in groundwater indicate greater biological activity inside the benzene plume than outside the benzene plume;
- Computer modeling runs could not be reasonably calibrated without assuming significant benzene biodegradation;

- An extensive body of research and literature is available to support that: a) the chemical pathways by which benzene degrades are well understood, b) benzene is known to biodegrade in a wide range of conditions in the laboratory, and c) benzene is known to biodegrade in a wide range of environmental conditions in the field, including those found at the Joint Site.

It is noted that any *one* of these factors, taken by itself, does not conclusively prove that intrinsic biodegradation of benzene is occurring in the benzene plume groundwater nor that it occurs reliably. However, when all lines of evidence are taken together, the case for reliable intrinsic biodegradation of benzene *in the benzene plume* is strong. These multiple factors not only indicate that biodegradation is occurring, but that it is occurring to an extent that the benzene plume in these units is being naturally contained by the intrinsic biodegradation process. Moreover, the extent of this naturally-contained plume essentially coincides with the TI waiver zone defined in Appendix E of the JGWFS and Section 10 of this ROD. It is therefore reasonable to conclude that intrinsic biodegradation can serve as a mechanism to meet the objectives for benzene plume containment for the UBF and MBFB Sand.

Reliance solely on monitored intrinsic biodegradation as a remedial mechanism for the benzene plume in the UBF and MBFB Sand is additionally appropriate for the following reasons:

- The UBF and the MBFB Sand have low permeability, which is 10 to 100 times less than the permeability of the MBFC Sand and the Gage and Lynwood Aquifers. Therefore, groundwater flow velocities, and consequently, rates of contaminant migration, are low in these units even in the absence of intrinsic biodegradation.

- These units are shallow and separated by several thick hydrostratigraphic units, including aquitards, from the units most likely to be used for drinking (although the State classifies all water under the site as having potential beneficial potable use). The result is that the risk associated with a failure of intrinsic biodegradation to contain the benzene plume in these two units would be low, provided containment is properly monitored.

Similar lines of evidence exist to support the presence of intrinsic biodegradation in the benzene plume in the MBFC Sand. Based on sampling conducted to date, it appears that the limited extent of the benzene plume in the MBFC Sand could be attributed to intrinsic biodegradation, which acts to contain the benzene in the UBF and MBFB Sand under the existing condition of the natural system. However, there is more uncertainty as to whether intrinsic biodegradation would be reliable to contain the benzene plume in the MBFC Sand, given the high permeability of the MBFC Sand, which could potentially result in higher contaminant migration velocities when hydraulic extraction is undertaken with the primary focus of reducing the chlorobenzene plume. In addition, the MBFC Sand is separated from the Gage Aquifer only by one layer, the LBF, which creates a higher risk with respect to contaminating deeper aquifers, including those more likely to be used for drinking, should intrinsic biodegradation fail to contain the contamination, making reliance on it more dubious. This is thoroughly discussed in Section 5 of the JGWFS and Section 12 of this ROD. EPA included one alternative in which intrinsic biodegradation is relied upon for containing the MBF**C** Sand, and several other alternatives where it is not relied upon. The evaluation and comparison of alternatives in Section 12 discusses the benefits and drawbacks of each.

Potential for Reliance on Intrinsic Biodegradation for the Chlorobenzene Plume

Recalling Sections 9 and 10, the remedial objectives for the chlorobenzene plume include containment within the containment/TI waiver zone, and reduction of large volume of the plume outside the containment/TI waiver zone. EPA has determined that intrinsic biodegradation of chlorobenzene is not a *reliable* mechanism to attain either objective. The basis for this determination, and its relation to the determination made for the benzene plume, is advanced in the following discussion.

The lines of evidence just discussed for the benzene plume do *not* apply to the benzene that is commingled with the chlorobenzene plume (this benzene is, by definition, *in* the chlorobenzene plume). This benzene has migrated up to three-quarters of a mile in the MBFC Sand from the former Montrose Chemical and Del Amo plants with no known intervening sources. EPA has considered two possible explanations for the observation that the benzene commingled with chlorobenzene appears to have moved a significant distance from the benzene sources, in contrast to the benzene that is not commingled with chlorobenzene. The first, and most probable, explanation is that the presence of chlorinated organic contaminants, such as chlorobenzene, retards the rate of biodegradation of benzene, allowing it to migrate further in groundwater before it degrades. The second possible explanation is that chlorobenzene itself is degrading to benzene within the chlorobenzene plume. EPA believes it is not likely that this is occurring sufficiently to create the observed concentrations of benzene in the chlorobenzene plume; moreover, chlorobenzene degradation, if it occurs, is not sufficiently understood in the field to confirm reliably that benzene would be a byproduct. Further discussion ensues.

In contrast to the benzene plume, sufficient lines of support for the presence of reliable intrinsic biodegradation of *chlorobenzene* at the Joint Site are not present. While intrinsic biodegradation of chlorobenzene may be occurring to some degree,

- The state of the chlorobenzene plume, especially the fact that the plume has been able to expand to its large lateral and vertical size, is not supportive of the presence of significant and dependable intrinsic biodegradation of chlorobenzene and indicates that such degradation is not likely to be substantial enough to rely upon as a remedial mechanism in remedy selection;

- The mechanisms by which chlorobenzene can be degraded in groundwater at the Joint Site, while outlined in theory, are only partially understood, are supported by a relative sparsity of laboratory studies, and are even less-well understood under field conditions, particularly in the conditions likely to exist at the Joint Site;

- Of the relatively few laboratory studies pertaining to biodegradation of chlorobenzene, those in which biodegradation occurred were performed under aerobic (oxygen present) conditions; other studies showed that biodegradation of chlorobenzene may be inhibited under anaerobic (oxygen absent) conditions; yet the conditions in the aquifers in which chlorobenzene contamination is extensive (in particular, the MBFC Sand and the Gage Aquifer) are likely to be anaerobic, not aerobic (for more information, see JGWFS).

The following two factors, in conjunction with the above observations, further imply that intrinsic biodegradation of chlorobenzene cannot be conclusively relied upon in a remedial context:

- The chlorobenzene is located in deeper aquifers with higher transmissivities. There is therefore greater potential for it to move more rapidly laterally and vertically, and it is closer to the aquifers most-likely to be readily used for drinking (it is noted that the State of California classifies all groundwater at the Joint Site as potential drinking water; the distinction made here is therefore one of the degree of likelihood of groundwater use, rather than of the classification of the aquifer). Moreover, because it becomes more difficult and expensive to characterize deeper aquifers fully, the deeper the contamination the more uncertainty associated with its long-term movement. These factors imply a greater risk associated with reliance on intrinsic biodegradation for the chlorobenzene plume, because the implications in the event that intrinsic biodegradation should fail are much more serious than for the shallower hydrostratigraphic units.

- It is unlikely that the biodegradation rate for chlorobenzene could be measured in the field with enough certainty that would allow for it to be used as a reliable remedial mechanism. The reasons for this were presented in detail in the JGWFS and in a letter from EPA to Montrose Chemical dated September 10, 1997. These reasons are also discussed in the Response Summary in this ROD, Response to Montrose Chemical Corporation, EPA Response ✍ 29.

Appendix B of this ROD provides explanations pertinent to the approach to characterization of intrinsic biodegradation for the benzene and chlorobenzene plumes.

Potential for Reliance on Intrinsic Biodegradation in the TCE Plume

The TCE plume, as defined in Section 7.2 of this ROD, is presently within the containment zone as defined in Section 10 of this ROD. There is no evidence to conclude that the TCE plume is subject to intrinsic biodegradation sufficient to keep it contained or to reduce its volume. As discussed in Section 7.3 of this ROD, (1) the range of rates of intrinsic biodegradation of TCE (and PCE) measured at other sites is much less (as much as 100 times slower) than the corresponding range for benzene, (2) limited modeling performed on TCE in the JGWFS, which assumed that TCE degrades at rates similar to those found at other sites, indicated significant migration of TCE would occur over time, particularly if hydraulic extraction is undertaken for the chlorobenzene plume, and (3) data from the remedial investigation indicate that TCE and PCE are migrating under existing conditions (that is, the TCE plume is not presently spatially stable with time). As with the chlorobenzene plume, intrinsic biodegradation may be occurring to some degree in the TCE plume. The significant rate of biodegradation of benzene in the benzene plume may be enhancing the rate of biodegradation of TCE in a process called co-degradation. This may, in fact, result in significant reductions in the field resident half-life of TCE at the Joint Site (and hence, the rate of its movement over time) compared to typical half-lives for TCE in the absence of benzene degradation. However, such processes cannot be *relied* upon with significant or sufficient certainty to the extent that they could be used as remedial mechanisms to contain or cleanup the TCE plume.

Basis for Using One Option for the TCE Plume in All Alternatives

All remedial alternatives that EPA considered in the remedial action selection process, other than Alternative 1, No Action, contained the same action for the TCE plume[2]. The rationale for including the same remedial action for TCE within the alternatives is presented below. The TCE action itself is discussed in Section 11.2. In general, there is both a need for a remedial action to contain the TCE plume, as well as significant limitations on the manner in which such an action can reasonably be implemented, due to the TCE plume's commingling and/or proximity to the benzene plume and benzene NAPL..

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[2]The reader is reminded that in this ROD, unless otherwise noted, the term TCE refers to the family of chlorinated solvents including trichloroethylene (TCE), perchloroethylene (PCE), trichloroethane (TCA), and dichloroethylene (DCE). The term "TCE plume" refers only to the TCE that is *not* commingled with chlorobenzene presently. The TCE plume lies, primarily, under the former Del Amo plant. See Section 7, "Summary of Site Characteristics," for discussion on the distribution of TCE.

Why a TCE Action Can Be Selected Despite Data Limitations

As mentioned earlier, the amount of data available regarding the TCE plume is comparatively less than that for the benzene and chlorobenzene plumes. The extent of the TCE plume at the Joint Site is bracketed spatially in the downgradient direction, and there is evidence as to the presence of sources of TCE contamination along the western border of the former Del Amo plant. The former Del Amo plant as well could have been a source of TCE. Because of the lesser amount of characterization data, TCE remedial scenarios were not directly modeled, and the TCE plume was addressed on a conceptual, performance-based level. In order to complete remedial design, additional confirmatory data on the TCE plume, including its exact extent in each of the hydrostratigraphic units as well as information about sources of TCE, is necessary.

EPA did not collect this data during the RI phase in part because the need for it was not apparent until late in the RI process, but *primarily* because the necessary approach to the TCE plume, from a remedy selection standpoint, is evident and supportable from the existing data, in large part due to the TCE plume's proximity to the benzene plume. The specific situation in which the TCE plume occurs means that less information is needed about it to *select* a remedy for it. This would not be the case if the benzene plume and benzene NAPL were not also present. This is described in more detail below. EPA acknowledges, however, that additional data about the TCE plume will be necessary to complete the remedial design phase, and this ROD requires that such data be collected (See Section 13, "Specification of the Remedial Action"). EPA also has the authority to amend the ROD if necessary to address conditions revealed during this sampling.

Why a Remedial Action for the TCE Plume is Necessary

As discussed in the section above regarding reliance on biodegradation, the data and information available suggest that the TCE plume is likely to move adversely in response to changes in hydraulic conditions, such as would occur from pumping in the chlorobenzene plume. In fact, data suggest that the TCE plume is migrating under current conditions, even before such pumping takes place. Laboratory and field studies indicate that under most conditions TCE biodegrades at significantly lower rates in the field than does benzene, which is proven to be highly and robustly biodegradable. The TCE plume appears to have moved farther from the apparent sources compared to benzene, despite the fact that the TCE sources may be younger than the Del Amo benzene sources. This is owing to the fact that the presence of the TCE in part may be due to sources which have come into operation since the close of the former Del Amo plant.

Based on this higher potential to move in response to adding outside hydraulic influences to aquifers nearby the TCE, containment of the TCE will be necessary to prevent adverse movement of the TCE. Moreover, intrinsic biodegradation cannot be relied upon to obtain this containment (see previous section). Intrinsic biodegradation of TCE, to the extent it occurs, will enhance the action selected by EPA for TCE and by assisting in keeping the TCE contained. However, active hydraulic containment, using hydraulic extraction with aquifer injection of treated water, will be necessary to keep the TCE contained.

Why Appropriate Versions of Active Hydraulic Containment for the TCE Plume are Limited

While it is necessary that hydraulic extraction be applied to the TCE plume, the manner in which it feasibly can be implemented is limited by its proximity to the high-concentration dissolved phase benzene and benzene NAPL. On this point, the following discussion addresses the MBFB Sand and MBFC Sand in turn.

In the MBFB Sand, the TCE plume is commingled with the dissolved phase benzene plume at high concentrations and the benzene NAPL in the benzene plume. Accordingly, using hydraulic extraction to remove the TCE from within the benzene plume would not a reasonable option, as it would require pumping the benzene plume in the fine grained upper units. This is a prospect which does not further the objective and requirement of containment, and, consequently, was screened from further consideration.

In the MBFC Sand, the TCE plume lies directly *under* the high-concentration dissolved phase benzene plume and NAPL in the MBFB Sand. Thus, either containing or reducing the concentrations of TCE in the MBFC Sand would require hydraulic extraction under the MBFB Sand contamination at the former Del Amo plant. Because of the thin stratigraphic separation between the MBFB Sand and the MBFC Sand, this would move some contamination downward from the MBFB Sand to the MBFC Sand. Such hydraulic extraction would impose significant risks and implementation problems because of the benzene NAPL lying directly above the MBFC Sand being pumped.

Based on existing data, EPA does not believe that hydraulic extraction directly under the benzene plume in the MBFB Sand is appropriate. If data collected in the remedial design phase indicates pumping of the MBFC Sand is necessary under the benzene plume and benzene plume NAPL in the MBFB Sand, EPA could modify the proposed remedy to include such a component to the remedial action. Instead, EPA's selected action for the TCE plume ensures that it remain contained within the containment zone, but does not require that pumping take place directly under the high concentrations of benzene in the MBFB Sand. This is consistent with other remedial action components in this ROD where the containment zone is affected by hydraulic pumping. In such cases, the extraction well or wells used to achieve the containment purposely have been located downgradient of the NAPL, rather than directly in the midst of or under the

NAPL, so as to avoid inducing the movement of the NAPL (and associated high dissolved concentrations of contaminant) downward.

In summation, if remedial objectives were to be attained, EPA did not have multiple options as to whether the TCE plume would be contained, nor as to whether or how hydraulic extraction would be used. EPA has selected the option for the TCE plume presented in Section 11.3. This option was included as a component in all alternatives considered, other than the No-Action alternative. This alternative is largely performance-based, and insures that: (1) the immediate TCE sources are partially contained by localized pumping in the MBFB and MBFC Sand, and that (2) the TCE plume remains contained within the containment/TI waiver zone. The TCE action is described in Section 11.3.

11.2 Characterizing Time Frames and Efficiencies

As discussed, the two most fundamental elements of this remedial action are: (1) containing the containment zone, and (2) eliminating the dissolved phase groundwater contamination outside the containment zone with concentrations above ISGS levels. The containment zone must be contained indefinitely, and this containment is accomplished by a combination of hydraulic extraction and treatment (with assistance from aquifer injection of treated water), and reliance on intrinsic biodegradation. Eliminating the dissolved phase contamination outside the containment zone is accomplished in every alternative by hydraulic extraction and treatment of groundwater. The concepts in this subsection place the performance characteristics of the alternatives into context.

Long Time Frames and How Time To Achieve Objectives Is Characterized

The duration of the remedial action selected by this ROD is long in two three respects:

- The presence and manner of occurrence of NAPL at the Joint Site requires that the containment zone remain contained *indefinitely*.

- The attainment of ISGS levels at all points in the chlorobenzene plume outside the containment zone (the part of the plume subject to plume reduction) will take a long time due to:

    - The large size of the plume and the number of hydrostratigraphic units affected;

    - The complexity (heterogeneity) of the subsurface, including relatively low-permeable zones, where achievable extraction rates of wells, and consequently the flushing rates, will be low.

These introduce complexities in terms of characterizing and evaluating the time to reach objectives.

It is important to note that cleanup of the contamination *inside* the containment zone is not a remedial objective of this action. It is true that over an extremely long time, all of the NAPL will eventually dissolve into the groundwater in the containment zone. However, this will not occur in a reasonable time frame. The process of NAPL dissolution is too complex and its completion too far removed in time to obtain any reasonable estimate of the time interval, other than to say that it may be on the order of centuries. This ROD does *not* consider NAPL dissolution to be a remedial mechanism, and the action for the containment zone is characterized as "indefinite containment," not "cleanup by dissolution." As such, the alternatives are not characterized in terms of the time for NAPL dissolution to be complete.

In contrast, eliminating the contamination above ISGS levels *outside* the containment zone *is* a remedial objective for this action, and hence the time required to accomplish this objective, and the relative rate and efficiency with which this occurs, are pertinent and appropriate characteristics within which to frame alternatives. Because the benzene and TCE plumes lie entirely within the containment zone to begin with, this objective applies solely to the chlorobenzene plume outside the containment zone.

As discussed in Section 11.1, the time frame to reach ISGS levels at all points in the groundwater outside the containment zone was evaluated in terms of the progress in approaching this objective, rather than by obtaining a total time frame directly from the model. This is because modeling simulations of cleanup time frames can only be used on a relative, not absolute, basis, and because the total time to clean up is longer than the time the model can reliably simulate.

Instead of characterizing and comparing alternatives based on the simulated total time to reach objectives, EPA compared their simulated relative performance within a 25-year time frame. The uncertainties associated with 25-year simulations are lower and the model's results are more reliable. The total time to reach the objective of eliminating the chlorobenzene plume outside the containment zone is inferred on a relative basis from each alternative's performance at 25 years. This provides a reasonable basis for comparison among alternatives in terms of total cleanup time, even though a certain value for the total cleanup time is not available.

As will be discussed in Section 11.3, the four alternatives other than No Action differ in terms of the relative aggressiveness with which the chlorobenzene plume outside the containment zone is reduced. However, the time needed for the volume of the chlorobenzene plume outside the TI waiver zone to shrink to zero is long (in excess of 50 years) even in the fastest alternative considered. This consideration, and the consideration that the containment zone must remain effective indefinitely, form a primary context for the characteristics, comparison and selection of alternatives which takes place in this Section and Section 12 of this ROD.

Early Time Performance

When using hydraulic extraction, aquifer injection and treatment to reduce the size of a plume, plume reduction often does not occur at a constant rate. It is the last fraction of plume reduction of the chlorobenzene plume, closest to the containment zone, which may be the most difficult and take the longest to remove. Some of the alternatives considered are able to remove a large majority of the plume very quickly, leaving only a small percentage of the plume to be addressed over the relatively long remainder of the remedial action. Other alternatives remove very little of the plume until very late in the total cleanup time. As just discussed, the time frame required to reach remedial objectives at all points in the chlorobenzene plume outside the containment zone is extended so it becomes appropriate to consider to what *degree* the remedial objectives are achieved in the interim period during the remedial action but prior to actually attaining remedial objectives. In this ROD, EPA refers to this concept as ***early time performance.***

Pore Volume Flushing

For the groundwater contamination which lies outside the containment zone, this remedial action relies on hydraulic extraction and aquifer injection, as discussed above. These actions induce hydraulic (pressure) gradients in the ground which force water to move. ***Flushing*** is the process by which dissolved contaminants are mobilized and removed by the water movement induced by hydraulic extraction and/or aquifer injection. In this process, contaminants adsorbed to soils in the saturated zone are induced to desorb (this occurs at a limited rate) into the dissolved phase. In short, flushing is the means by which hydraulic extraction and aquifer injection accomplish the "cleaning" of the aquifer. ***Pore volume flushing*** is a measure of the number of times the volume of water in the interstitial pores in the soil will be exchanged per unit time through a hydraulic extraction/aquifer injection system.

Two factors of importance with respect to pore volume flushing are its magnitude and its distribution. Pore volume flushing is typically optimized during remedial design of the wellfield. However, this remedy selection process examined the issue of general overall pumping rate ("aggressiveness") in reducing the chlorobenzene plume, in light of potential adverse migration and plume interactions. Therefore, an evaluation is appropriate on a general level as to whether each alternative will (1) produce significant pore volume flushing and (2) whether given an approximate overall pump rate, pore volume flushing can be reasonably distributed to cover the entire portion of the chlorobenzene plume outside the containment zone. EPA has therefore characterized the alternatives in terms of pore volume flushing prior to making the formal comparison of alternatives.

Pore volume flushing rate magnitudes and distributions, simulated for each of the remedial alternatives, can be found in Appendix B of the JGWFS.

11.3 Elements Common to All Alternatives

Containment Zone and Restoration Outside the Containment Zone

As discussed in Sections 4 and 10 of this ROD, all alternatives considered by EPA in this remedial selection process (other than the No Action Alternative, Alternative 1) follow the approach of hydraulically containing a zone of groundwater around the NAPL, thereby isolating it from the remainder of the groundwater, which can then be cleaned. In keeping with this approach, all alternatives considered for this remedy other than No Action include a Technical Impracticability (TI) waiver for certain ARARs, to be applied to a zone of groundwater (shown in Figure 10-1), in which contaminants in groundwater are indefinitely contained. This was thoroughly discussed earlier in Section 10 of this ROD. The TI waiver zone and containment zone refer to the same physical space.

Contingent Actions

All of the alternatives except for No Action utilize hydraulic extraction and treatment as the means by which a substantial portion of the containment zone is contained. All alternatives except for No Action also rely upon monitored intrinsic biodegradation as the means by which the balance of the containment zone is contained. The basis for this reliance is discussed in a later subsection of this section. The degree to which monitored intrinsic biodegradation is relied upon varies in some of the alternatives, as discussed below. In general, under all alternatives other than No Action, all of the containment zone within the chlorobenzene plume is contained by hydraulic extraction, and some or all of the benzene plume is contained by reliance on monitored intrinsic biodegradation, depending on the alternative.

Because it is a passive and pre-existing natural condition, the efficacy of intrinsic biodegradation must be consistently monitored when it is applied. Moreover, it is not only appropriate but necessary that contingent and active measures be available should monitoring indicate that the remedial objective of containment is not being met by the passive process. Where it is applied by this ROD, monitored intrinsic biodegradation is relied upon solely to the extent that it successfully contains dissolved phase contamination within the containment zone. Should it fail to do so, hydraulic extraction and treatment shall be implemented as a contingent action, replacing monitored intrinsic biodegradation as the means of containment in such areas.

It is not possible at the time of issuing the ROD to specify exactly all aspects of the contingent action that would be taken if reliance on intrinsic biodegradation fails to contain the benzene plume where it is applied. This would be impractical because the number of possible types of failure is very large. The nature of any given containment transgression, including its vertical and lateral location, extent, and contributing causes, cannot be foreseen in advance but would largely determine the detailed aspects of the contingent remedial action appropriate to correcting the transgression (e.g. where to apply extraction, injection, how to modify local pump rates, etc.) These aspects are largely a matter of design adjustments during the operation and maintenance phase of the remedial action. This ROD therefore specifies, on a performance basis, that contingent actions will be determined and undertaken in order to restore the condition of containment and that such actions will utilize active hydraulic extraction and treatment. Aquifer injection has the capability to alter aquifer hydraulics and assist in effecting or restoring containment. Where it is appropriate, and can be utilized in accordance with ARARs, aquifer injection can be used to supplement hydraulic extraction and treatment for such purposes.

Provisions for contingent actions are more fully detailed in Section 13.

Monitoring

All of the alternatives, except the No Action Alternative, include long-term and continual monitoring to confirm containment, remedial action performance, and other factors mentioned more specifically below and in Section 13. All of the alternatives also require periodic well surveys, both of private and public wells, to ensure that groundwater is not being used in a manner that would present an unacceptable health risk within the area of groundwater contamination that remains as the remedial action progresses.

Additional Data Acquisition

All of the alternatives, except the No Action alternative, would require that additional data be collected at the Joint Site, including but limited to:

- Data sufficient to further identify TCE sources within the Joint Site and to characterize the exact extent of its distribution;

- Data to further characterize the benzene plume in the MBFB Sand under the butadiene plancor of the former Del Amo plant; and

- Data to further characterize the downgradient extent of the pCBSA plume.

Institutional Controls

All alternatives other than No Action would include certain institutional controls.

Existing legal and regulatory requirements exist that may limit the use of groundwater in the contaminated area at the Joint Site. However, EPA is not in control of these requirements, in that EPA cannot ensure that (1) these authorities will remain “on the books” for the duration of this remedial action, and that (2) these requirements will be enforced in accordance with the requirements of this ROD. Among these requirements are the adjudication of the Los Angeles Groundwater Basin, as described in Section 7, as well as limitations and requirements on well installations imposed by the State Water Resources Control Board. As discussed in Section 7, these controls cannot be relied upon by EPA to be effective in the long term other than as an enhancement to the proposed remedy. This is particularly important given the long time frame over which this remedy must remain in place. Because the groundwater contamination covers literally thousands of separately-owned real property parcels, imposing direct institutional controls on real property throughout the entire distribution of groundwater contamination at the Joint Site would be impracticable.

Superfund regulations clearly state that, while institutional controls should be considered as a means for supplementing a remedy, they should not be relied upon as the sole remedy. The NCP, at §300.430(a)(1)(iii)(D), states,

> EPA expects to use institutional controls such as water use and deed restrictions to supplement engineering controls as appropriate for short- and long-term management to prevent or limit exposure to hazardous substances, pollutants, or contaminants...The use of institutional controls shall not substitute for active response measures (e.g. treatment and/or containment of source material, restoration of groundwaters to their beneficial uses) as the sole remedy unless such active measures are determined not to be practicable, based on the balancing of trade-offs among alternatives that is conducted during the selection of the remedy.

Similarly, EPA notes that the NCP preamble, at 55 Fed. Reg. No. 46, p.8706, notes that:

> “...institutional controls may be used as a supplement to engineering controls over time but should not substitute for active response measures as the sole remedy unless active response measures are not practicable...”

This remedial action contains certain institutional controls to supplement the primary actions selected in this ROD, which include both containment and restoration of groundwater resources through treatment as preferred by the NCP. All alternatives other than No Action include the following institutional controls:

1. EPA would coordinate with the appropriate agencies regarding the existing legal and regulatory prohibitions and restrictions on groundwater use for the affected groundwater at the Joint Site.

2. At its sole discretion, EPA may issue administrative non-interference orders within its authority to ensure that actions taken by outside parties do not interfere with the Joint Site remedial action. Non-interference orders are administrative orders issued by EPA pursuant to CERCLA which direct a party to cease or desist from taking an action that would interfere with EPA's remedy, and/or to take actions specified in the order to prevent or mitigate such an interference. As an example, if a facility outside the periphery of the Joint Site has groundwater contamination is moving or will move into the Joint Site during the remedial action, EPA may issue an order directing that party to take actions that will prevent such interference. Likewise, if such a party were implementing its own groundwater cleanup using hydraulic extraction, and such extraction threatened to create hydraulic changes that would threaten the effectiveness of the remedial action selected by this ROD, EPA could issue such an order directing that the party cease and desist or modify its remedial actions in such a way that such interference is avoided.

3. EPA would perform well surveys to monitor groundwater use within the area of groundwater affected by contamination at the Joint Site. If well users within the area are found, EPA would inform such persons directly of the substantial health risk and also inform the State and local agencies which have jurisdiction and/or authority with respect to groundwater wells and groundwater usage within the Joint Site. Also, EPA may issue non-interference orders, at its discretion, to prevent or limit operation of wells which may be found to exist within the contaminated groundwater at the Joint Site in the future.

With respect to potential interferences from outside sources of contamination, in addition to issuance of non-interference orders as discussed above, EPA may consider amending this ROD to select specific remedial actions for such sources as part of the Joint Site, if EPA should determine that such actions become necessary during the remedial design or implementation of the remedial action.

Common Elements for the *Chlorobenzene* Plume

All of the alternatives (except No Action, Alternative 1) contain the following aspects with respect to the *chlorobenzene plume*:

- The volume of the chlorobenzene plume *outside the containment zone/TI waiver zone* that contains contaminants at concentrations above ISGS levels is reduced to zero.[3]

- This reduction of volume of the chlorobenzene plume *outside the containment zone/TI waiver zone* is accomplished by hydraulic extraction, treatment, and aquifer injection.

- The volume of the chlorobenzene plume *inside the containment zone/TI waiver zone,* surrounding the NAPL*,* is contained indefinitely. The extent of the TI waiver zone was identified in Section 10.

- The containment zone/TI waiver zone is contained by means of hydraulic extraction, treatment, and aquifer injection. NAPL itself is not removed as part of this remedy (unless incidental). Rather, water into which the NAPL has dissolved is removed and treated within a zone of groundwater which surrounds the NAPL.

- The majority of the hydraulic extraction will take place, in roughly balanced amounts, in the MBFC Sand and the Gage Aquifer. Some extraction will also take place in the Lynwood Aquifer.

- Aquifer injection of treated water. As discussed earlier, this is necessary for hydraulic control and to ensure that the movement of NAPL is not unreasonably induced by the pumping, and so it is included in all alternatives.

- Monitoring sufficient to confirm and evaluate the plume reduction outside the containment zone, the containment of the containment zone, movements of contaminants within the plumes, groundwater levels, gradients, hydraulics, effects of pumping, and other factors.

- Contingent hydraulic extraction in the event that contamination leaves the containment zone (to which the TI waiver is applied).

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[3]Alternatives 2-5 differ in terms of the relative aggressiveness, or rate, that the cleanup of the chlorobenzene plume outside the containment zone would occur. These differences are discussed in Section 11.3, which discusses the differentiating aspects of the alternatives.

- A TI waiver applied to the MBFB Sand, MBFC Sand, Lower Bellflower, and Gage Aquifer. The Lynwood Aquifer is not included in the TI waiver and therefore Lynwood groundwater within the Joint Site will be restored to concentrations at or below ISGSs (See Section 10). The containment/TI waiver zone extends deeper within the chlorobenzene plume than within the benzene plume.

Common Elements for the *Benzene* Plume

The benzene plume lies entirely within the containment/TI waiver zone and so, under all alternatives considered other than the No Action Alternative, is not subject to volume reduction (e.g. shrinking the volume of water in the plume with contaminants at unacceptable concentrations), but rather containment. The basis for this was discussed in Section 10 of this ROD. The means used to contain the benzene plume varies among the alternatives, as is discussed in Section 11.4, following this section.

Under all alternatives except for No Action, this ROD sets a performance requirement that the benzene plume remain contained within the containment zone/TI waiver zone. Under all alternatives except No Action, if the benzene plume leaves the containment zone in the future, additional active hydraulic extraction and treatment of the benzene plume would be implemented to re-establish hydraulic containment of the benzene within the TI waiver zone.

The following are also components of all alternatives (except Alternative 1) for the ***benzene plume***:

- Monitoring sufficient to confirm and evaluate containment of the benzene plume, the movement of contaminants within the benzene plume, the continued effectiveness of intrinsic biodegradation within the benzene plume, groundwater levels, gradients, hydraulics, effects of pumping, and other factors.

- A TI waiver applied to the UBF, MBFB Sand and MBFC Sand, but not to the Gage or Lynwood Aquifers. See Section "Technical Impracticability ARAR Waivers" in this ROD. As described in that section, there is a single TI waiver zone for the Joint Site but it extends to a lesser depth for the benzene plume than for the chlorobenzene plume.

Common Elements for the *TCE* Plume

Under all alternatives, a performance-based approach is applied to the TCE plume, requiring that the TCE, like the benzene, remain contained within the containment zone (TI Waiver zone). Under this approach, as with benzene, if the TCE moves outside the containment zone, hydraulic extraction would be employed to re-establish containment. This contingent hydraulic extraction would not take place under the benzene NAPL, but at the periphery of the containment zone; hence, risks of benzene movement would be minimized (See earlier discussion in Section 11.1).

The remedial action for the TCE plume in all alternatives, other than the No Action alternative, contains or addresses the following:

- The immediate sources of TCE contamination in the TCE plume (near solvent-using facilities upgradient of the MW-20 area) will be partially contained by pumping groundwater at low rates near these sources and treating it. This hydraulic extraction will not be directly under the benzene NAPL in the MBFB Sand, but will take place slightly upgradient of the NAPL. This hydraulic extraction will limit the highest concentrations of TCE, as well as TCE NAPL from migrating laterally and vertically, although it will not completely prevent the migration of the TCE.

- Treated water from this hydraulic extraction will be re-injected back into the aquifer to obtain the optimum flushing and ability to limit hydraulic influences on the neighboring benzene NAPL and/or chlorobenzene plume.

- Additional sampling during remedial design will confirm the exact size and nature of the TCE plume in the MBFC Sand for design purposes. If the data reveal unexpected information, adjustments to the remedy will be proposed and implemented by EPA, as necessary.

- On a performance basis, TCE that is currently within the containment zone (TI waiver zone, established as described earlier in this ROD) will not be allowed to leave the containment zone. While hydraulic extraction of the TCE in the MBFC Sand directly under the benzene NAPL in the MBFB Sand is not proposed, additional pumping wells downgradient of the TI waiver zone and/or under the MBFC Sand in the Gage Aquifer may be required to meet this performance requirement and such needs will be assessed during the remedial design phase.

As this action for the TCE plume does not further vary among the alternatives, it is not further described in the discussion differentiating the alternatives that follows.

Actions for the Contaminant pCBSA

All alternatives, except for the No Action alternative, contain the following actions with respect to the compound pCBSA. The rationale for taking these actions is presented in Section 12, however, as some of the information in the remainder of Section 11 provides part of the basis for this action. However, the actions for pCBSA are noted here so that all common-elements can be listed together.

pCBSA is being addressed separately from all other contaminants by this remedial action. Therefore, the requirements specified elsewhere in this ROD for the chlorobenzene, benzene, and TCE plumes do not apply to pCBSA. All alternatives other than the No-Action alternative contain the following actions for pCBSA. Section 12 provides much more detail on the rationale for this action.

- The concentration at which pCBSA is re-injected into the ground shall be limited to 25,000 ppb. The State of California holds that 25,000 µg/l can be considered a provisional health standard for pCBSA with respect to injected groundwater. This requirement is a non-promulgated standard of the State of California (See Section 8 of this ROD), however, it is selected by this ROD as a performance standard for injected groundwater.

- The full downgradient extent of pCBSA contamination shall be determined and the movement of pCBSA shall be routinely monitored.

- Sampling at potentially susceptible public production wells shall include analyses for pCBSA.

- Well surveys shall be routinely updated to identify any new wells which may lie within the pCBSA distribution.

- At the Superfund 5-year reviews required by law, EPA will re-evaluate whether additional toxicological studies have been performed for pCBSA, assess the extent of the pCBSA plume and make determinations as to whether the remedy remains protective with respect to pCBSA.

It should be noted that the 25,000 ppb limit on aquifer injection of treated water mentioned above is ***not*** an in-situ standard. Therefore, this value does not represent an ISGS value. This ROD standard applies to the action of aquifer injection after groundwater is withdrawn and treated; it does not imply that groundwater in the ground will be cleaned to this value.

11.4 Differentiating Description of Alternatives

A summary of major elements of alternatives is shown in Figure 11-1, and in Table 11-1. These figures greatly facilitate the discussion in this subsection as well as the previous subsection.
Figure 11-1 is arranged visually by hydrostratigraphic unit. It provides a summary of both the common and differing elements of the alternatives in terms of how the containment zone is contained, and the means by which the contaminant concentrations in any portion of the plume outside the containment zone are reduced (the volume of the plume reduced) so as to attain ISGS concentration levels within the aquifer. Table 11-1 provides similar information in tabular format, but also shows information related to the TCE plume, aquifer discharge methods, and cost, which are not shown on Figure 11-1 for simplicity. It is noted that Table 11-2 contains more detailed cost information than Table 11-1.

A description of elements that are common among the alternatives was provided above. The following discussion provides a description of the differing elements of the alternatives that were considered as part of the remedial action selection process. The representative technologies and discharge options are also shown for each alternative. Further discussion of the treatment technologies and discharge options are discussed in the next section. Because the action for the TCE plume is common to all alternatives, it is not discussed in this section.

Detailed and overall cost information that is cited in the following discussion is summarized in Table 11-2 of this ROD.

Alternative 1

Alternative 1 is No Action. Under this alternative, no remedial action would be taken, and no monitoring would occur. It has no cost in terms of remedial actions, although there would clearly be a cost to society from the continued loss of the groundwater resource and the potential for human exposure to site contaminants. Contamination would continue to move unchecked and unmonitored. NAPL would continue to contaminate groundwater. Potential health risks, if realized, would not be abated. Existing groundwater contamination would remain indefinitely, on the order of several centuries, and would potentially continue to impact new areas.

Introduction to Alternatives 2 Through 5

The four active alternatives (2-5) differ in key respects with respect to the chlorobenzene plume and benzene plume, respectively.

Chlorobenzene Plume

Alternatives 2 through 5 differ in terms of the relative *aggressiveness,* or *rate,* with which the chlorobenzene plume *outside* the containment zone is reduced in volume. Three groundwater extraction rates for the chlorobenzene plume are reflected in alternatives 2-5: 350 gallons per minute (gpm), 700 gpm, and 1400 gpm. In the JGWFS, these pump rates represent the *Plume Reduction 1, Plume Reduction 2, and Plume Reduction 3 scenarios* for the chlorobenzene plume. In general, the higher the pump rate, the faster the cleanup would occur, and the greater the flushing of the pore spaces in the aquifer by the remedial action.

Each of these scenarios was modeled in the JGWFS using differing wellfields. While the basic structure of each of these wellfields was the same, the numbers of extraction and injection wells were increased as the overall target pumping rate being simulated was increased. *It should be noted that these wellfields are not selected by this ROD; wellfields will be adjusted during the remedial design phase.* Those wishing to see the wellfields used in the JGWFS should view Section 5 or Appendix B of the JGWFS.

Figure 11-2 shows the performance of each alternative at removing the chlorobenzene plume outside the containment zone at simulated time frames of 10, 25, and 50 years. The primary relative basis of comparison used in the text which follows is the 25 year simulation. It is noted that pore volume flushing rate magnitudes and distributions can be found in Section 5 of the JGWFS.

Benzene Plume

Alternatives 2 through 5 differ in terms of the means by which the benzene plume is contained (as discussed in Section 10, the entire benzene plume is within the containment zone). In Alternative 2, the benzene plume is contained in all units by reliance on monitored intrinsic biodegradation. In Alternatives 3, 4 and 5, the benzene plume is contained in the UBF and MBFB sand by reliance on monitored intrinsic biodegradation, but is contained in the MBFC Sand by active hydraulic extraction and treatment. This was called ***hybrid containment*** in the JGWFS because both methods were used to contain the benzene plume, depending on the hydrostratigraphic unit.

EPA eliminated from further consideration alternatives that would have relied on intrinsic biodegradation for the MBFC Sand in the benzene plume while the chlorobenzene plume was pumped at the higher 700-gpm and 1400-gpm pump rates. This was because there was too much uncertainty that intrinsic biodegradation could keep the benzene plume contained in the MBFC Sand if the chlorobenzene plume is pumped at these rates.

Alternative 2
350 gpm for Chlorobenzene / Containment by Intrinsic Biodegradation for Benzene

Under Alternative 2, the chlorobenzene plume outside the containment zone would be reduced using hydraulic extraction, treatment, and aquifer injection, at a rate of approximately **350 gpm**. Because of this low pump rate, the time to complete the remedy is the longest of any of the alternatives (excluding No Action, in which a cleanup is not undertaken). After 25 years, the model predicts that somewhat less than one third of the volume of the chlorobenzene plume (with concentrations above drinking water standards) would be removed. From Figure 11-2, it can be seen that Alternative 2 removes very little of its contamination in the early years of operation. Thus, Alternative 2 exhibits relatively poor early time performance.

The area with measurable and significant pore volume flushing under Alternative 2 is limited to about one half the size of the chlorobenzene plume and the spatial coverage of significant pore volume flushing is sporadic. Significant areas of the chlorobenzene plume, therefore, will be flushed at low rates and other areas will virtually not be flushed at all.

Under alternative 2, the benzene plume would be contained in the UBF, the MBFB Sand, and the MBFC Sand through reliance on monitored intrinsic biodegradation.

The cost of Alternative 2 would be $21,353,000.[4]

Alternative 3
350 gpm for Chlorobenzene / Hybrid Containment for Benzene

Under Alternative 3, as with Alternative 2, the chlorobenzene plume outside the containment zone would be reduced using hydraulic extraction, treatment, and aquifer injection, at a rate of approximately **350 gpm**. As with Alternative 2, after 25 years, the model predicts that somewhat less than one third of the volume of the chlorobenzene plume with concentrations above ISGS

[4] Cost values given below differ slightly from those in the JGWFS because they have been corrected after a spreadsheet error was discovered in the JGWFS during the public comment period. The cost estimates change by the following amounts due to this error: Alternative 2, 2.4 percent; Alternative 3, 2.0 percent; Alternative 4, 1.7; and Alternative 5, 1.6 percent. These amounts are not considered significant relative to the -30%/+50% cost estimating used for feasibility study purposes. For more information on this error, see Response Summary.

levels would be removed. Alternative 3 has the same characteristics as Alternative 2 with respect to total relative time to meet objectives, early time performance, and pore volume flushing.

Under alternative 3, the benzene plume would be contained in the UBF, and the MBFB Sand through reliance on monitored intrinsic biodegradation. The benzene plume in the MBFC Sand would be contained by active hydraulic extraction and treatment. This is called *hybrid containment.*

The cost of Alternative 3 would be $26,481,000.

Alternative 4
700 gpm for Chlorobenzene / Hybrid Containment for Benzene

Under Alternative 4, the chlorobenzene plume outside the containment zone would be reduced using hydraulic extraction, treatment, and aquifer injection, at a rate of approximately **700 gpm**, as opposed to 350 gpm in Alternatives 2 and 3. Alternative 4 would stop the chlorobenzene plume from spreading almost immediately and begin to reduce its size. The higher 700 gpm pump rate provides for excellent early time performance (a large percentage of the plume is removed in early years of operation), and a shorter overall cleanup time, compared to Alternatives 2 and 3. At 25 years, the model predicts that slightly more than two-thirds of the chlorobenzene plume with concentrations above ISGS levels would be removed. The pore volume flushing by this Alternative is greater in magnitude (flushing rates of 1 pore volume per year and higher are achieved in the chlorobenzene plume, and pore volume flushing covers the entire plume).

Under alternative 4, as with Alternative 3, the benzene plume would be contained in the UBF, the MBFB Sand only through reliance on monitored intrinsic biodegradation. The benzene plume in the MBFC Sand would be contained by active hydraulic extraction and treatment. This is called *hybrid containment.*

The cost of Alternative 4 would be $30,490,000.

Alternative 5
1400 gpm for Chlorobenzene / Hybrid Containment for Benzene

Under Alternative 5, the chlorobenzene plume outside the containment zone would be reduced using hydraulic extraction, treatment, and aquifer injection, at a rate of approximately **1400 gpm**. After 25 years, the model predicts that about 90 percent (varies between MBFC Sand and Gage Aquifer) of the volume of the chlorobenzene plume with concentrations above ISGS levels would be removed. Based on these estimates, the total time to reach remedial objectives would be the least among the alternatives. The early time performance of Alternative 5 is excellent and is the best of any of the alternatives. The pore volume flushing under Alternative 5 is greater in magnitude and in extent than Alternative 4; in fact, it was simulated to create appreciable pore volume flushing over an area larger than the chlorobenzene plume (this excess, however, would be removed during the remedial design process if Alternative 5 were designed and implemented).

Under alternative 5, as with Alternatives 3 and 4, the benzene plume would be contained in the UBF, the MBFB Sand only through reliance on monitored intrinsic biodegradation. The benzene plume in the MBFC Sand would be contained by active hydraulic extraction and treatment. This is called *hybrid containment.*

The cost of Alternative 5 would be $40,514,000.

11.5 Treatment Technologies and Treated Water Discharge

Each of the alternatives considered by EPA in the JGWFS, except for Alternative 1, No Action, employs treatment of extracted groundwater for one or more areas of groundwater. The treated groundwater must be discharged in some manner.

Locations of Treatment and Number of Treatment Plants

The JGWFS makes reasonable assumptions as to the number and locations of groundwater treatment plants so as to make reasonable estimates of costs associated with the alternatives. Three treatment plants were assumed, one for each plume, for alternatives 3, 4 and 5. For Alternative 2, in which no active hydraulic containment is assumed for the benzene plume in the MBFC Sand, only two plants are assumed. For Alternative 1, No Action, no plants are assumed. However, this ROD does not select the number of treatment plants, wellfields, nor pump rates at individual wells, and these will be set in remedial design.

Primary Treatment Technologies

The primary differences among the remedial alternatives considered by EPA lie in what each alternative is able to accomplish in the ground rather than which technology is used to accomplish treatment of the extracted water. Treatment technologies were thoroughly evaluated as part of this remedy selection process, taking into account each of the plumes from which water would be extracted. However, this ROD selects several possible technologies to be available in remedial design.

Primary treatment technologies were those which were deemed capable of attaining ISGS levels in the groundwater outside the containment zone with respect to the contaminants in groundwater. Such technologies would also be capable of treating water drawn from *inside* the containment zone (in the process of containment of the containment zone) to discharge standards. Additional *ancillary treatment technologies* were evaluated subsequently in order to ensure compliance with treated water discharge requirements (ancillary technologies are discussed following this subsection). The primary technologies identified in the JGWFS, after screening, to address the Joint Site contaminants are (1) liquid phase and vapor phase carbon adsorption, (2) air stripping, and (3) fluidized bed reactor. These are shown on Figure 11-3. With **liquid phase adsorption**, the water coming into the treatment plant is run through a bed of activated carbon, which adsorb the contaminants out of the water. When the carbon can no longer adsorb more contaminants, the carbon is said to be saturated. The saturated carbon can be sent offsite and reactivated, or regenerated, which allows the contaminants to be safely recovered and destroyed, and the carbon beads can be reused. Alternatively, the carbon can be sent to a landfill designed and approved to receive hazardous waste. **Liquid phase granular activated carbon** is the form of liquid phase adsorption most likely to be cost-effective at the Joint Site. With **air stripping**, the water is contacted with air and the volatile contaminants are transferred into the air. The air is then passed through a **vapor phase carbon adsorption** system that transfers the contaminants from the air to the carbon, similar to what occurs in liquid phase adsorption. The clean air is then discharged back into the atmosphere. With **fluidized bed reactor**, the contaminated water is passed through a agitated bed which has carbon with a biological film , or biofilm, on it. The bacteria in the biofilm metabolize and degrade most of the contaminants into carbon dioxide, water, and hydrochloric acid. There is the need to dispose of a portion of the biological mass that grows in the biofilm. When necessary, the biological mass is concentrated, dewatered, and disposed offsite in accordance with independently applicable laws and requirements.

Treatment Trains

The JGWFS did a screening and evaluation of these technologies, taking into account the water quality, approximate pumping locations and pump rates, and discharge options to be applied. Primary treatment technologies were assembled into treatment trains.

From the three primary technologies, EPA considered three treatment trains for the chlorobenzene plume, three treatment trains for the benzene plume, and two treatment trains for the TCE plume. These are:

- Chlorobenzene Plume:

  Carbon adsorption alone
  Air stripping followed by carbon adsorption polishing and vapor phase adsorption
  Fluidized bed reactor followed by carbon adsorption polishing

●Benzene Plume:

Carbon adsorption alone
Air stripping followed by carbon adsorption polishing and vapor phase adsorption
Fluidized bed reactor followed by carbon adsorption polishing

●TCE Plume:

Carbon adsorption alone
Air Stripping followed by vapor phase carbon adsorption

These basic treatment trains were further enhanced by ancillary technologies shown in Table 11-3 and discussed below, to form the complete treatment trains, as shown in Table 11-4.

Ancillary Technologies

Ancillary technologies are those required to treat extracted groundwater to reduce the concentration of naturally-occurring species in the water to meet regulatory standards and engineering requirements associated with the discharge of the water. The JGWFS identified the major such ancillary technologies anticipated to be necessary in the alternatives, and incorporated them in the treatment trains evaluated for each plume in the JGWFS. As an example, the natural level of copper in the benzene plume is slightly too high to meet standards for discharge to a storm channel, the discharge option for water treated from the benzene plume in the MBFC Sand. Ancillary technologies identified in the JGWFS include those that may be necessary to reduce ambient copper levels in groundwater prior to injection into a storm water system, reduce total dissolved solids prior to re-injection, or prevent scaling or fouling of injection wells. These are shown in Table 11-3. These technologies shall be used in the remedial action where necessary and shall be considered available in remedial design. Ancillary technologies shall be used only to the extent that the remedial design requires them.

Cost-representative Treatment Train versus Selection of Multiple Technologies

For each plume, a ***cost-representative treatment train*** was identified in the JGWFS. In each case, the cost-representative treatment train was the least costly option using the assumptions used by the JGWFS and after determining largely equal ability of all the treatment trains to meet regulatory requirements, including ARARs. For purposes of estimating costs, the cost-representative treatment train was assumed to be used for each plume. In this way, the costs of all alternatives could be compared on an even basis.

For all three plumes, the JGWFS identified Carbon Adsorption Alone (with ancillary treatments as necessary) as the *cost-representative treatment*. Accordingly, the cost estimates of alternatives in the JGWFS assumed that Carbon Adsorption Alone was the treatment. EPA's calculations indicate that Carbon Adsorption Alone is likely to be the most cost-effective option for each plume once the remedy is designed. However, the JGWFS does provide sufficient information to determine the cost of an alternative primary treatment technology in the event that a different treatment train were used.

By identifying a cost-representative treatment, this ROD does not intend to limit the remedial design to this one treatment method. Rather than selecting a single treatment technology or treatment train for each plume, this ROD selects the entire range of treatment trains, and the primary technologies which passed screening, as available in remedial design to address each plume. This is to allow for maximum flexibility in the design. This ROD identifies all ARARs that shall apply to these technologies, in Appendix A to this ROD.

Supplemental Technologies

In addition to the primary treatment trains, and ancillary technologies, the JGWFS identified other technologies which survived screening and could be added to the treatment trains in modular fashion, if determined necessary in remedial design or during the course of the remedial action. It is not intended that these additional technologies be available as wholesale alternatives (replacements) to the primary treatment trains identified above. Switching the entire treatment to one of these additional technologies could imply a dramatic change in the cost of the remedial action which was not evaluated as part of the Feasibility Study or remedial action selection process. However, such ***supplemental technologies*** could be added to the remedial action for certain portions of groundwater, for certain times during the remedial action, to address problems or issues with might arise, or to increase the efficiency of the remedial system already in place. These supplemental technologies should be considered available in remedial design as determined necessary by the remedial design. The supplemental technologies considered in the JGWFS include ***liquid-gravity separation*** and ***advanced oxidation processes.***

Discharge Options

As discussed earlier in this section, aquifer injection is considered the essential disposal option for the treated water for the chlorobenzene plume and the TCE plume. This is to provide hydraulic control and limit the potential for NAPL movement. Therefore, no other discharge options were evaluated in detail by EPA for the chlorobenzene and TCE plumes. However, three discharge options were evaluated for the benzene plume, for alternatives where the benzene plume is subject to hydraulic extraction. These are: (1) aquifer injection, (2) discharge to the storm drain, and (3) disposal to the sanitary sewer. Discharge to the Storm Drain was the representative discharge option used in the remedial alternatives for the benzene plume. The basis for this is described in the JGWFS, Section 7.

As with the primary technologies and treatment trains just discussed, by selecting a representative discharge option, this ROD does not intend to restrict the discharge options for the benzene plume to only storm water discharge. Any of the three discharge options identified shall be available in the remedial design, provided all discharge ARARs and other requirements are met by the implemented remedial action.

The ISGS levels established in Section 9 of this ROD apply to the in-situ groundwater. However, in order to ensure protectiveness of human health and the environment, and ensure progress toward meeting ISGS levels in-situ in groundwater, treated groundwater shall not be injected into aquifers at the Joint Site as part of this remedial action at concentrations which exceed the ISGS levels.

Table 11-1
Description of Alternatives
Record of Decision for Dual Site Groundwater Operable Unit
Montrose Chemical and Del Amo Superfund Sites

			Faster Cleanup →	→	→
	Alternative 1 "No Action"	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**
CHLOROBENZENE PLUME					
Approximate Rate of Hydraulic Extraction	No action	350 gallons per minute	350 gallons per minute	700 gallons per minute	1,400 gallons per minute
Method of Hydraulically Isolating NAPL Area	No containment of the NAPL area	Extracting and treating the groundwater	Extracting and treating the groundwater	Extracting and treating the groundwater	Extracting and treating the groundwater
Where is the Treated Water Discharged?	No action, thus no discharge	Aquifer injection	Aquifer injection	Aquifer injection	Aquifer injection
BENZENE PLUME					
Approximate Rate of Hydraulic Extraction	No action	No hydraulic extraction for benzene plume	Approximately 40 gallons per minute	Approximately 40 gallons per minute	Approximately 40 gallons per minute
Method of Hydraulically Containing Benzene Plume	No containment of the benzene plume	Contain benzene plume in all units with intrinsic biodegradation	Contain the UBF and MBFB Sand with intrinsic biodegradation Contain the MBFC Sand with extracting and treating the groundwater	Contain the UBF and MBFB Sand with intrinsic biodegradation Contain the MBFC Sand with extracting and treating the groundwater	Contain the UBF and MBFB Sand with intrinsic biodegradation Contain the MBFC Sand with extracting and treating the groundwater
Where is the Treated Water Discharged?	No action, so no discharge	No treated water to discharge	Storm Drain	Storm Drain	Storm Drain
TCE PLUME					
What is Done? (Same in all alternatives except No. 1)	No action	Extracting and treating groundwater to partially contain the sources; TCE is not allowed to spread beyond TI waiver zone	Extracting and treating groundwater to partially contain the sources; TCE is not allowed to spread beyond TI waiver zone	Extracting and treating groundwater to partially contain the sources; TCE is not allowed to spread beyond TI waiver zone	Extracting and treating groundwater to partially contain the sources; TCE is not allowed to spread beyond TI waiver zone

Table 11-1 - CONTINUED
Description of Alternatives
Record of Decision for Dual Site Groundwater Operable Unit
Montrose and Del Amo Superfund Sites

			Faster Cleanup ➞	➞	➞
	Alternative 1 "No Action"	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**
COSTS OF THE ALTERNATIVES					
Total 30-Year Present Worth*:	$0	$21,353,000	$26,481,000	$30,490,000	$40,514,000
Capital Cost:	$0	$12,402,000	$13,976,000	$16,028,000	$22,049,000

EPA's Preferred Alternative

*Costs are calculated as 30-year present worth, even though the true duration of the remedy is likely to be greater than 30 years. This is reasonable because the present worth value of the dollar after 30 years is small under a reasonable depreciation rate. For instance, EPA ran calculations which showed that if the cost basis were extended to 100 years, instead of 30 years, the total present worth value would increase by only about 12 percent, assuming a 5-percent depreciation rate. Because the true total time to clean up cannot be known exactly (time frames for alternatives are compared on a relative, not absolute, basis) EPA believes that the 30-year present worth value is an acceptable estimate and basis for comparison of the total costs of the alternatives in this case.

Table 11-2
Costs of Alternatives

Record of Decision for Dual Site Groundwater Operable Unit
Montrose Chemical and Del Amo Superfund Sites

Alternative	Cost Summary	Monitoring	Benzene Hybrid Containment	Chlorobenzene Plume Reduction	TCE Plume Reduction	Total Cost Summary
2	Capital	$806,000	$0	$8,989,000	$2,607,000	$12,402,000
	Present Worth O&M	$2,057,000	$0	$4,338,000	$2,180,000	$8,575,000
	Present Worth Equipment Replacement	97,000	0	155,000	124,000	376,000
	Total Present Worth	**$2,960,000**	**$0**	**$13,482,000**	**$4,911,000**	**$21,353,000**
3	Capital	$806,000	$1,574,000	$8,989,000	$2,607,000	$13,976,000
	Present Worth O&M	$2,057,000	$3,381,000	$4,338,000	$2,180,000	$11,956,000
	Present Worth Equipment Replacement	97,000	173,000	155,000	124,000	549,000
	Total Present Worth	**$2,960,000**	**$5,128,000**	**$13,482,000**	**$4,911,000**	**$26,481,000**
4	Capital	$806,000	$1,574,000	$11,041,000	$2,607,000	$16,028,000
	Present Worth O&M	$2,057,000	$3,381,000	$6,237,000	$2,180,000	$13,855,000
	Present Worth Equipment Replacement	97,000	173,000	213,000	124,000	607,000
	Total Present Worth	**$2,960,000**	**$5,128,000**	**$17,491,000**	**$4,911,000**	**$30,490,000**
5	Capital	$806,000	$1,574,000	$17,062,000	$2,607,000	$22,049,000
	Present Worth O&M	$2,057,000	$3,381,000	$10,141,000	$2,180,000	$17,759,000
	Present Worth Equipment Replacement	97,000	173,000	312,000	124,000	706,000
	Total Present Worth	**$2,960,000**	**$5,128,000**	**$27,517,000**	**$4,911,000**	**$40,514,000**

Notes: Present worth operations & maintenance (O&M) costs calculated at 5-percent discount rate for 30 years.

Costs are calculated as 30-year present worth, even though the true duration of the remedy is likely to be greater than 30 years. This is reasonable because the present worth value of the dollar after 30 years is small under a reasonable depreciation rate. For instance, EPA ran calculations which showed that if the cost basis were extended to 100 years, instead of 30 years, the total present worth value would increase by only about 12 percent, assuming a 5-percent depreciation rate. Because the true total time to clean up cannot be known exactly (time frames for alternatives are compared on a relative, not absolute, basis) EPA believes that the 30-year present worth value is an acceptable estimate and basis for comparison of the total costs of the alternatives in this case.

Table 11-3
Ancillary Treatment Technologies
Record of Decision for Dual Site Groundwater Operable Unit
Montrose Chemical and Del Amo Superfund Sites

Control Requirement	Treatment Technologies
Heavy Metals Removal	– Iron Coprecipitation: (benzene plume storm drain discharge)
Mineral Scale Control	– pH Adjustment – Lime Softening: (benzene plume injection) – Antiscalent (sequestering agent) Addition: (all plumes, all discharge options)
pH Control	– Carbon Dioxide Addition (all plumes following air stripping) – Mineral Acid Addition (Benzene plume storm drain discharge following iron coprecipitation)
Biological Slime Control	– Bleach Addition (all plumes, all discharge options)
Suspended Solids Control	– Clarifiers (where applicable) – Media Filtration (where applicable) – Fine Filtration (all plumes, all discharge options)

Table 11-4
Treatment Trains

Record of Decision for Dual Site Groundwater Operable Unit
Montrose Chemical and Del Amo Superfund Sites

<u>Chlorobenzene Plume</u>
Air Stripping Followed by LGAC Adsorption and VGAC for Offgas Treatment
LGAC Adsorption
Fluidized-Bed Reactor Followed by LGAC Adsorption

<u>Benzene Plume</u>
Air Stripping Followed by Iron Coprecipitation, LGAC Adsorption, and VGAC for Offgas Treatment
LGAC Adsorption with Iron Coprecipitation
Fluidized-Bed Reactor Followed by Iron Coprecipitation and LGAC Adsorption

<u>TCE Plume</u>
Air Stripping Followed by LGAC Adsorption and VGAC for Offgas Treatment
LGAC Adsorption

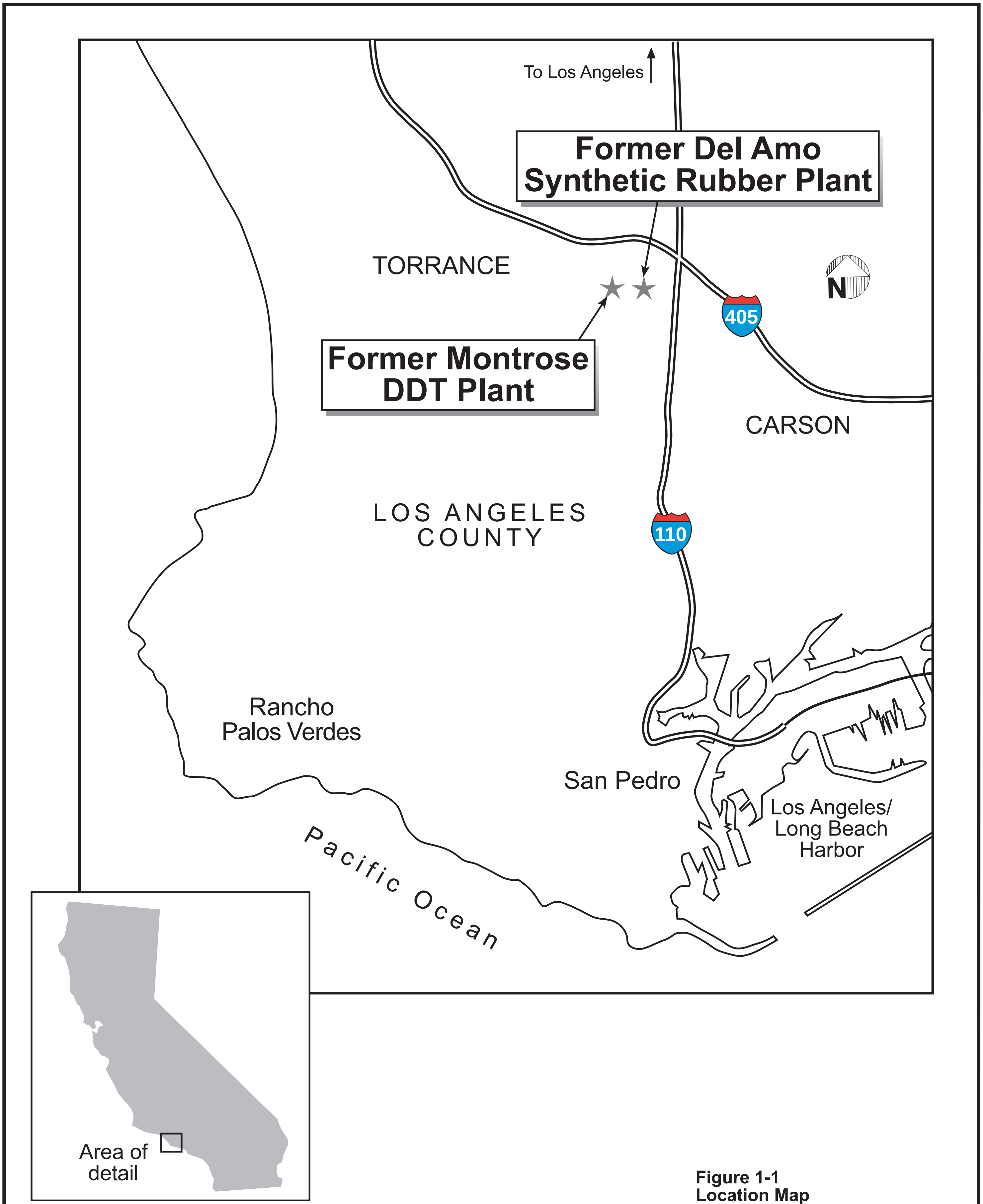
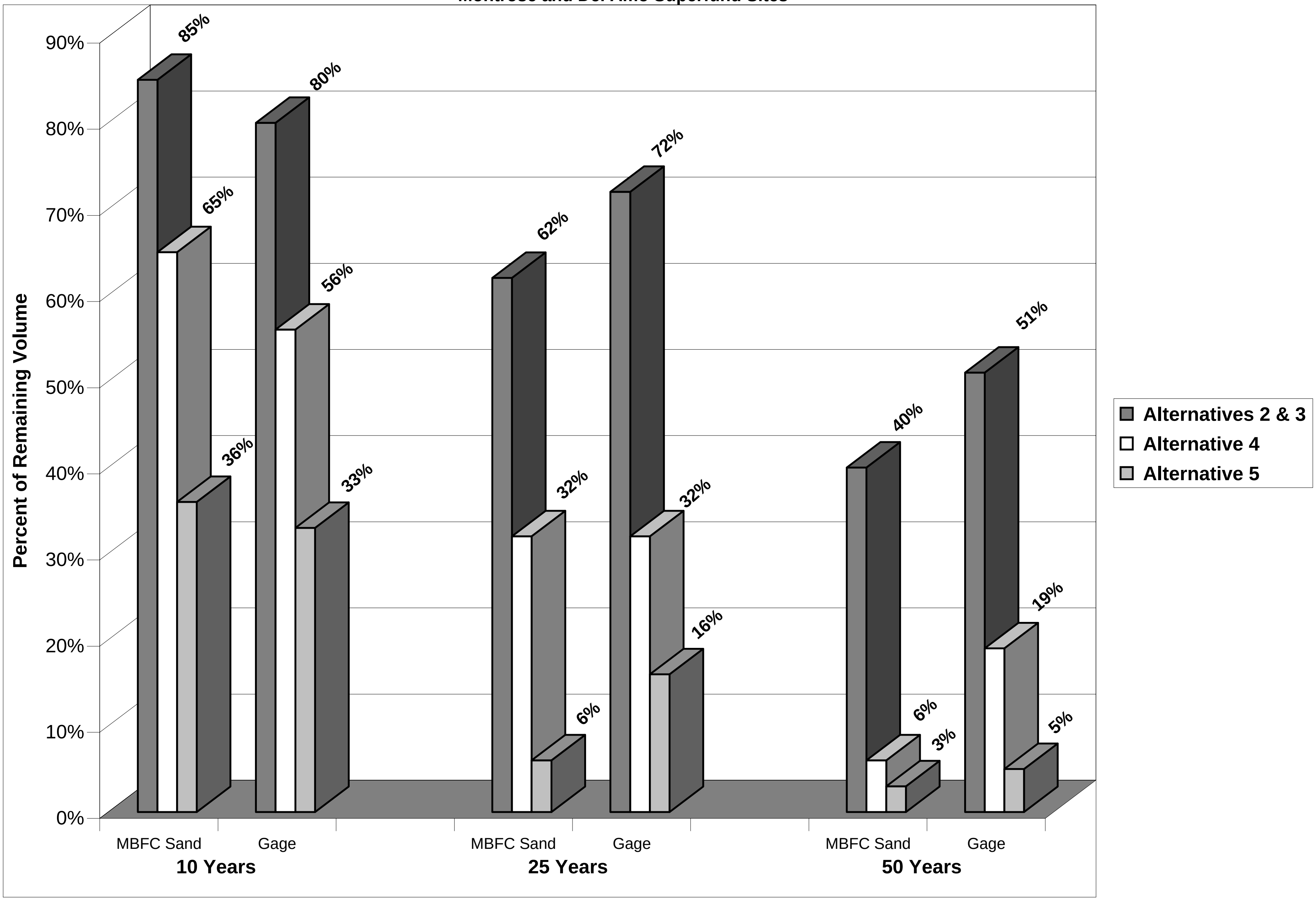


Figure 1-1
Location Map
Record of Decision
Dual Site Groundwater Operable Unit
Montrose and Del Amo Superfund Sites

EPA **US EPA Region IX**

Figure 11-2
Percent of Remaining Volume of the Chlorobenzene Plume[1]
by Alternative in 10, 25, and 50 Years
Record of Decision
Dual Site Groundwater Operable Unit
Montrose and Del Amo Superfund Sites



[1] The dissolved chlorobenzene outside the DNAPL containment zone

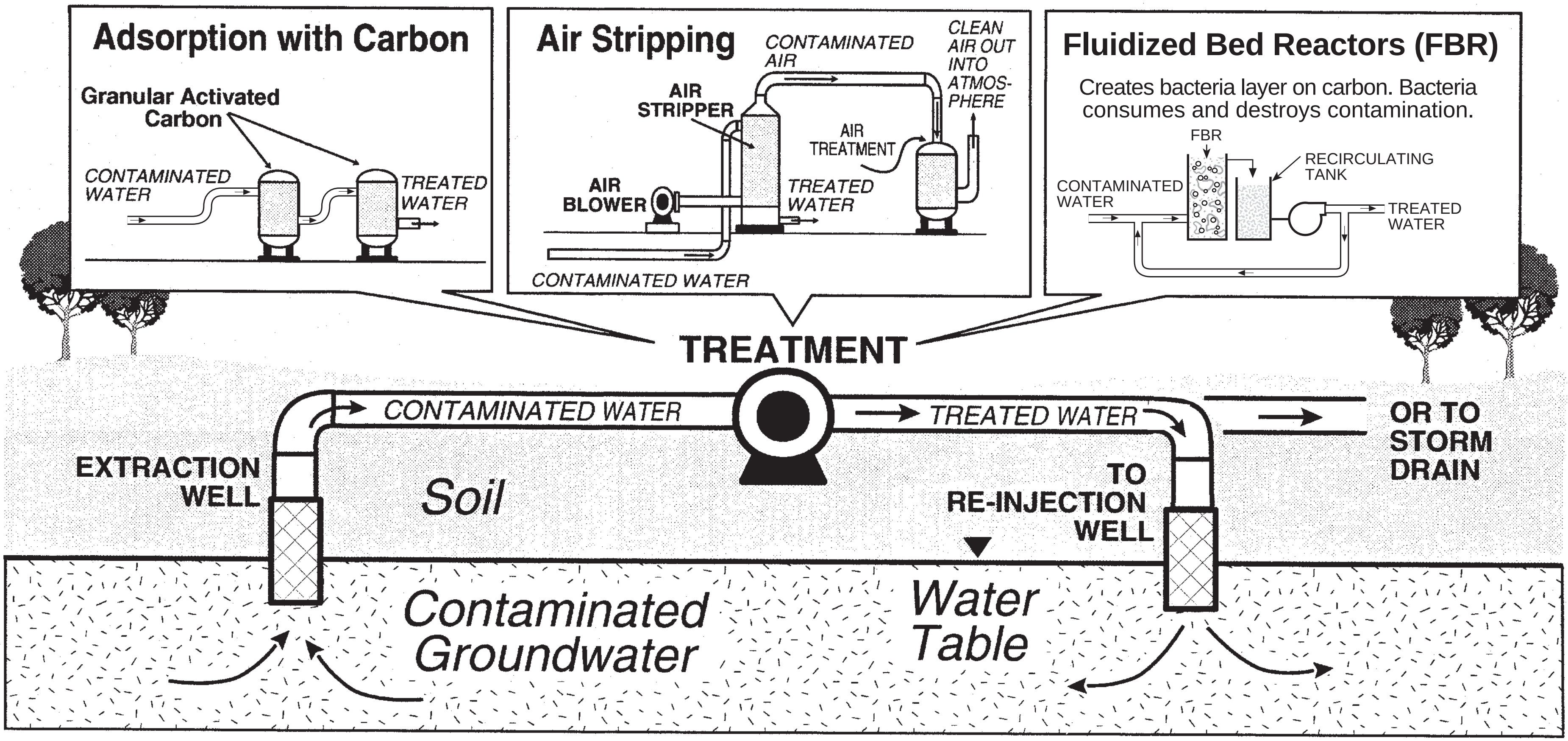


Figure 11-3
Treatment Technologies
Record of Decision
Dual Site Groundwater Operable Unit
Montrose and Del Amo Superfund Sites

Table 11-4
Treatment Trains

Chlorobenzene Plume
Air Stripping Followed by LGAC Adsorption and VGAC for Offgas Treatment
LGAC Adsorption
Fluidized-Bed Reactor Followed by LGAC Adsorption
Benzene Plume
Air Stripping Followed by Iron Coprecipitation, LGAC Adsorption, and VGAC for Offgas Treatment
LGAC Adsorption with Iron Coprecipitation
Fluidized-Bed Reactor Followed by Iron Coprecipitation and LGAC Adsorption
TCE Plume
Air Stripping Followed by LGAC Adsorption and VGAC for Offgas Treatment
LGAC Adsorption

*See treatment trains include the necessary treatment technologies